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France et al.

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(54) **VALVE ASSEMBLY**

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(73) Assignee: **Aeroquip Corporation**, Maumee, OH (US)

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Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(51) **Int. Cl.**[7] **F16K 31/524**
(52) **U.S. Cl.** **251/263**; 251/257; 251/325; 251/340
(58) **Field of Search** 257/149.4, 148, 257/152, 214, 215, 226, 227, 251, 252, 229, 253, 256, 257, 262, 263, 325, 335.2, 340

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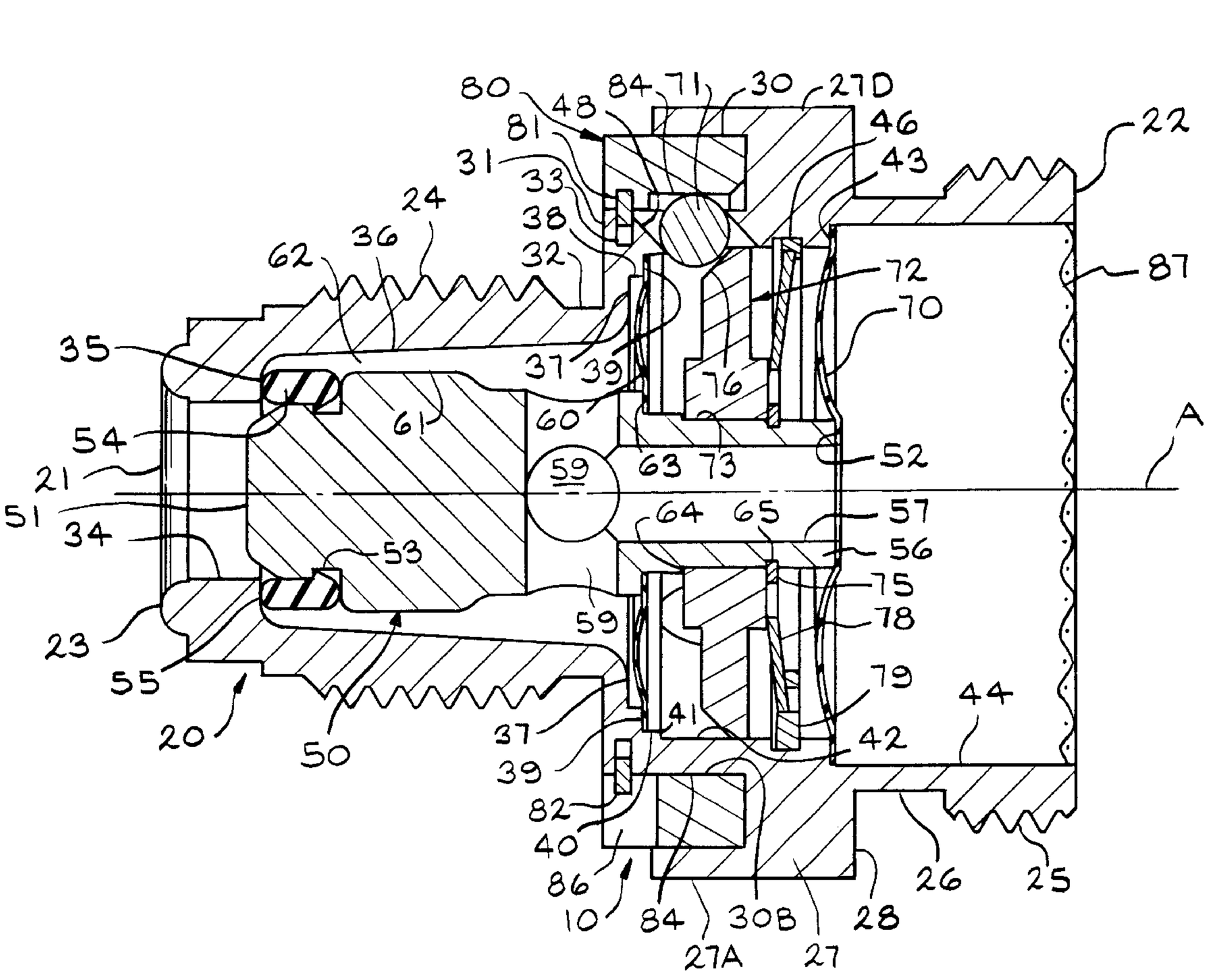
(57) **ABSTRACT**

A valve assembly includes a poppet axially moveable in a passageway of a body member. The poppet has an annular seal sealingly engageable with a sealing abutment of the body and, when so engaged, blocks the flow of fluid between the first end of the body and the second end of the body. A rotatable actuator imparts axial movement to the poppet to move the annular seal from the positioned engaged to the shoulder to a positioned spaced from the shoulder.

19 Claims, 8 Drawing Sheets



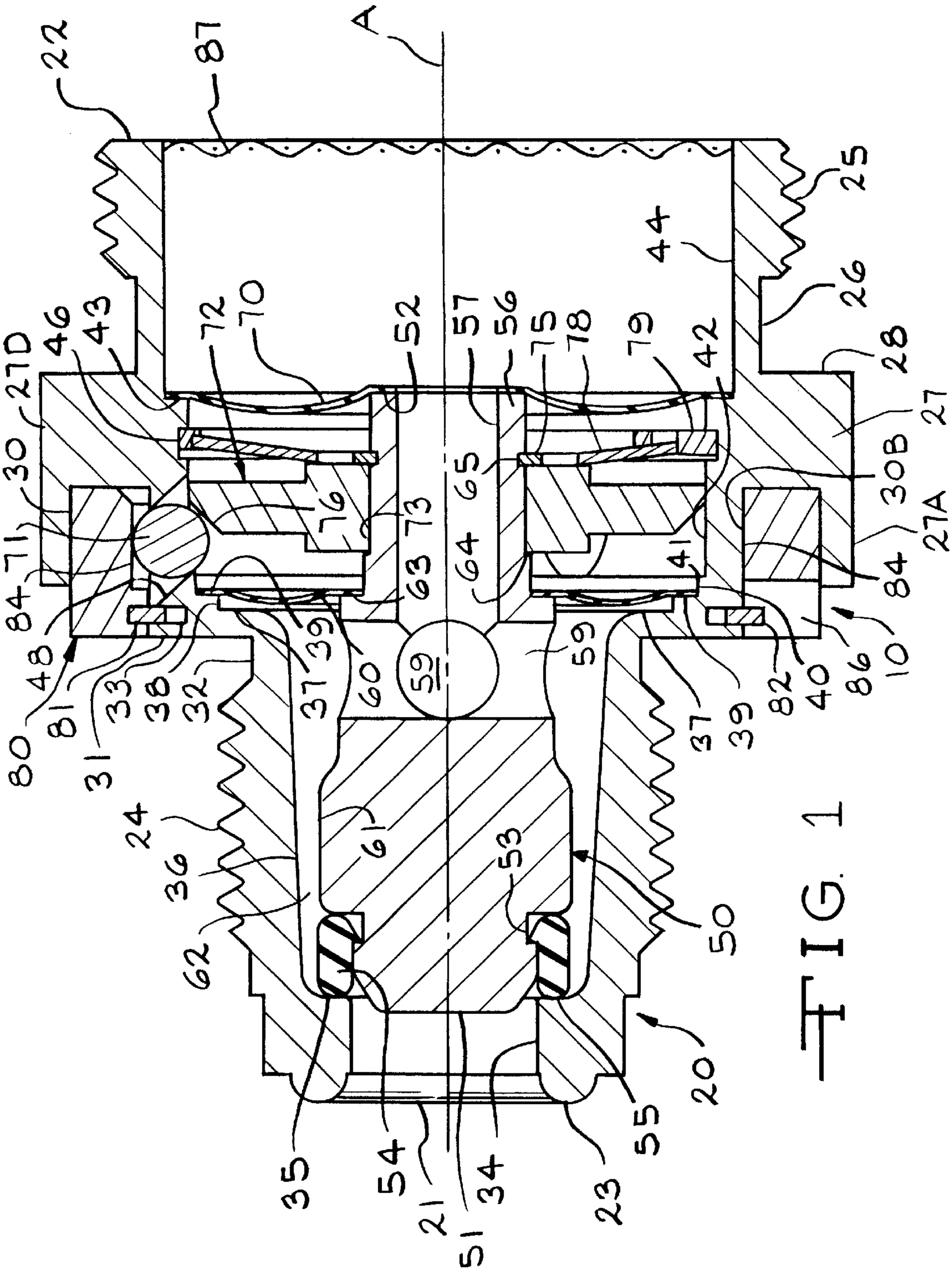

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FIG. 1

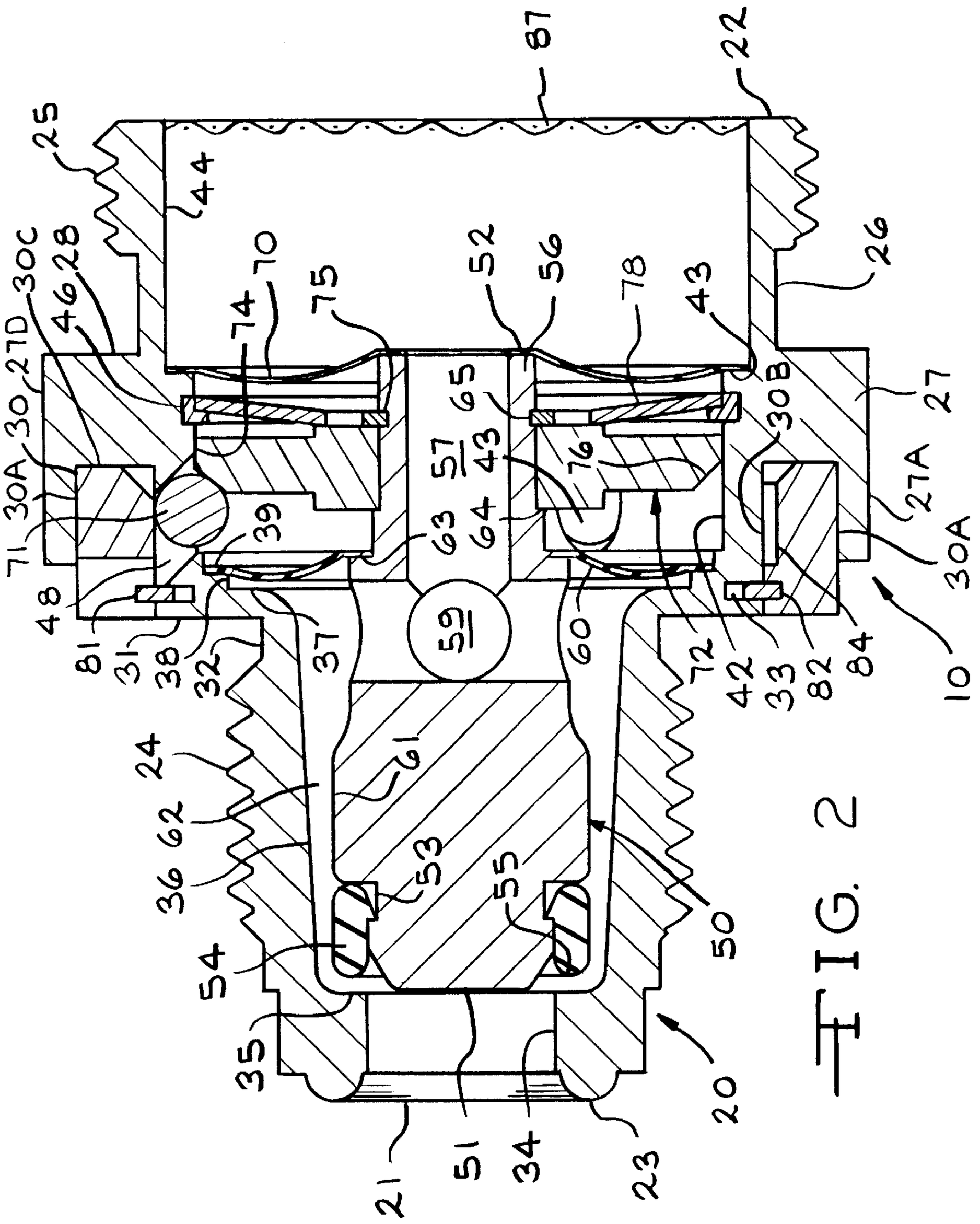
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FIG. 2

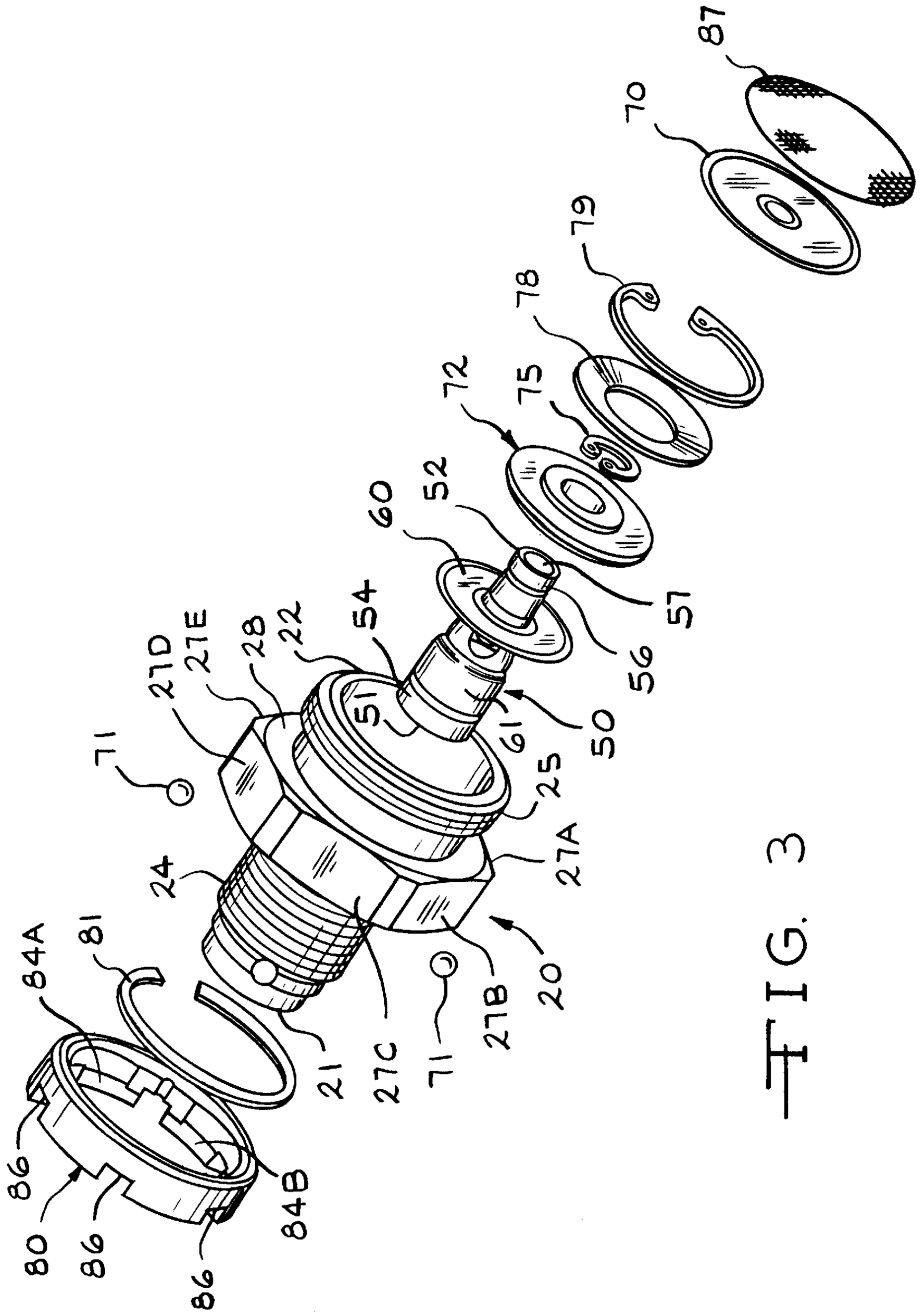
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FIG. 3

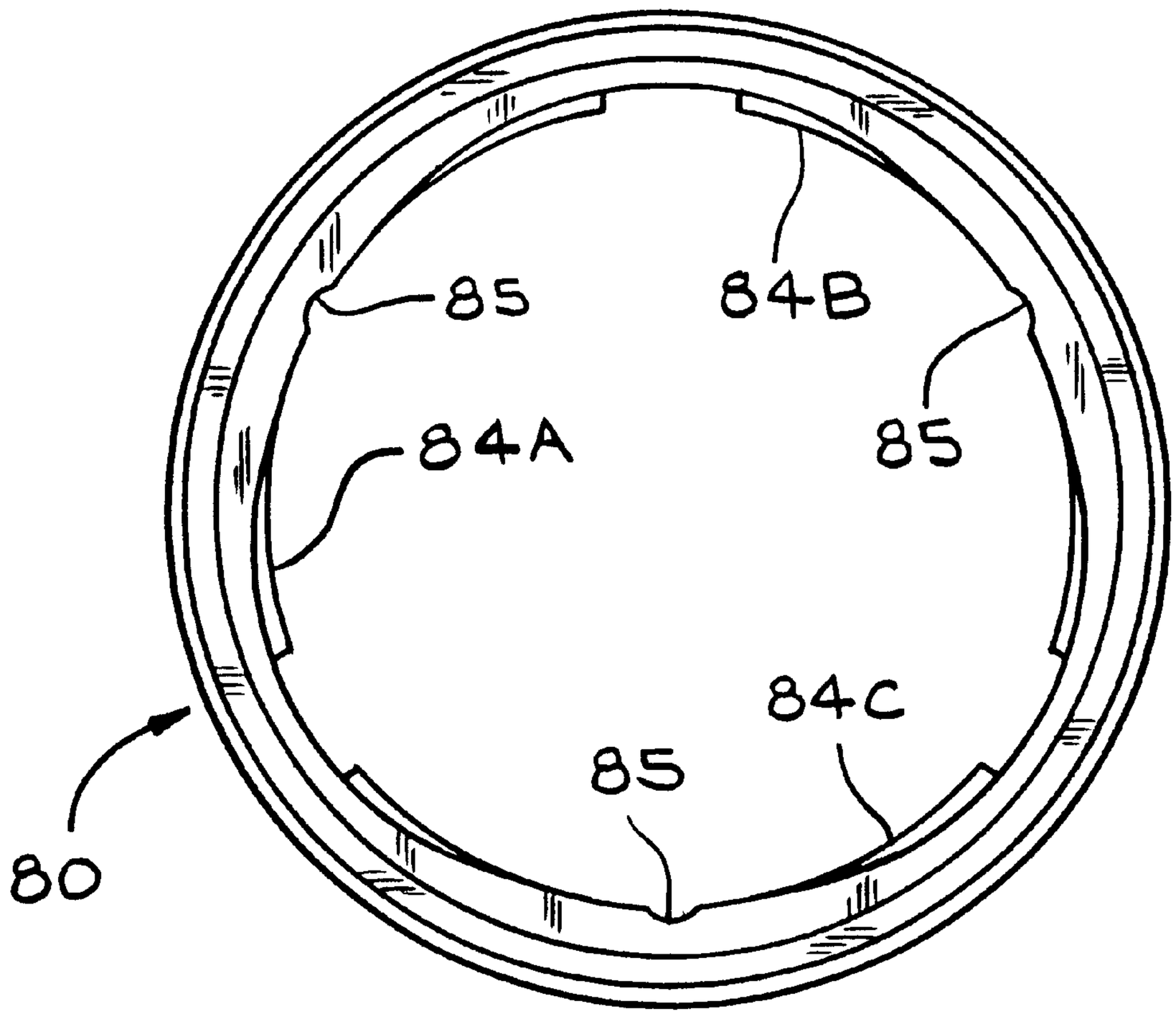

FIG. 4

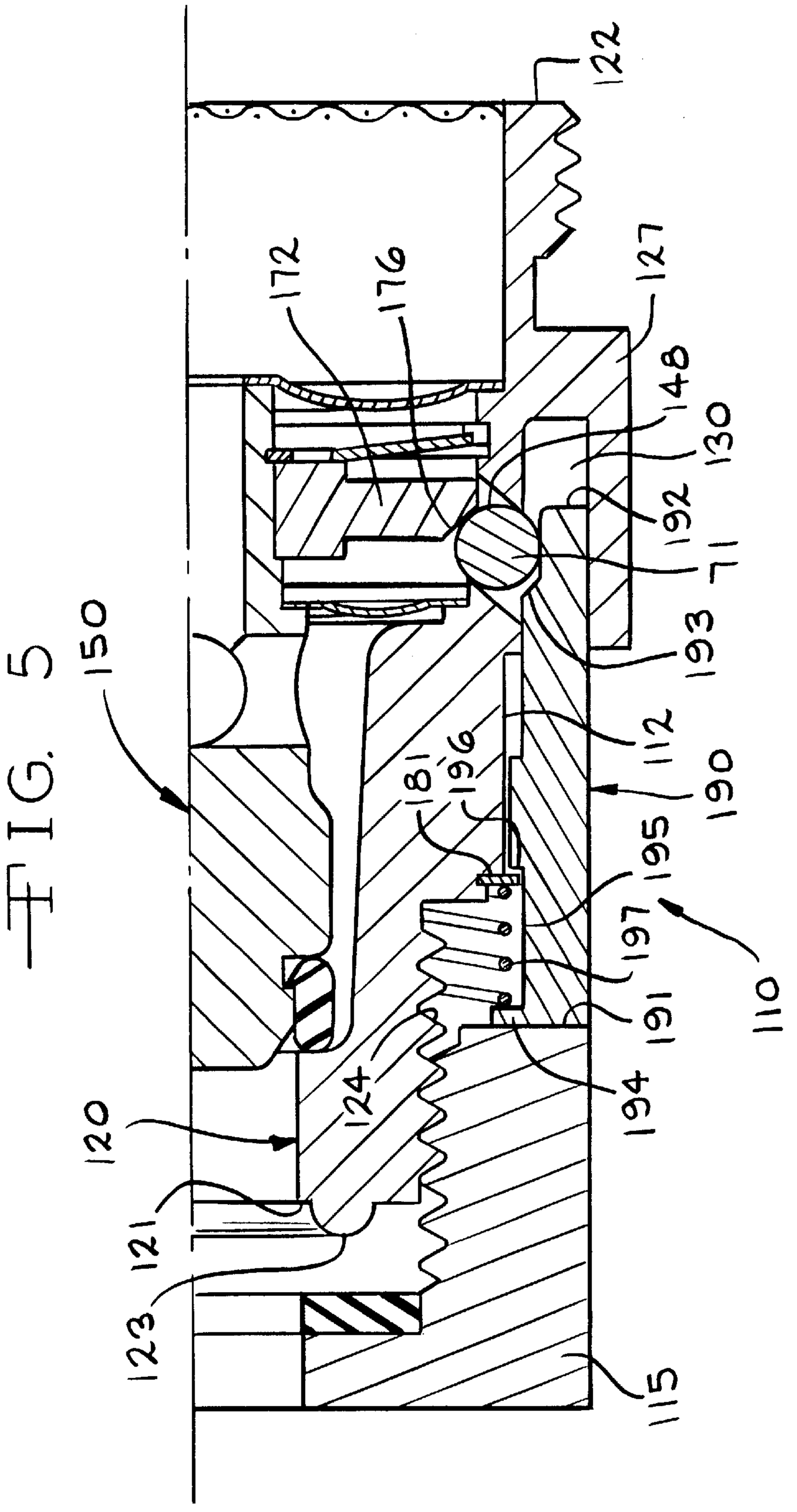
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FIG. 5

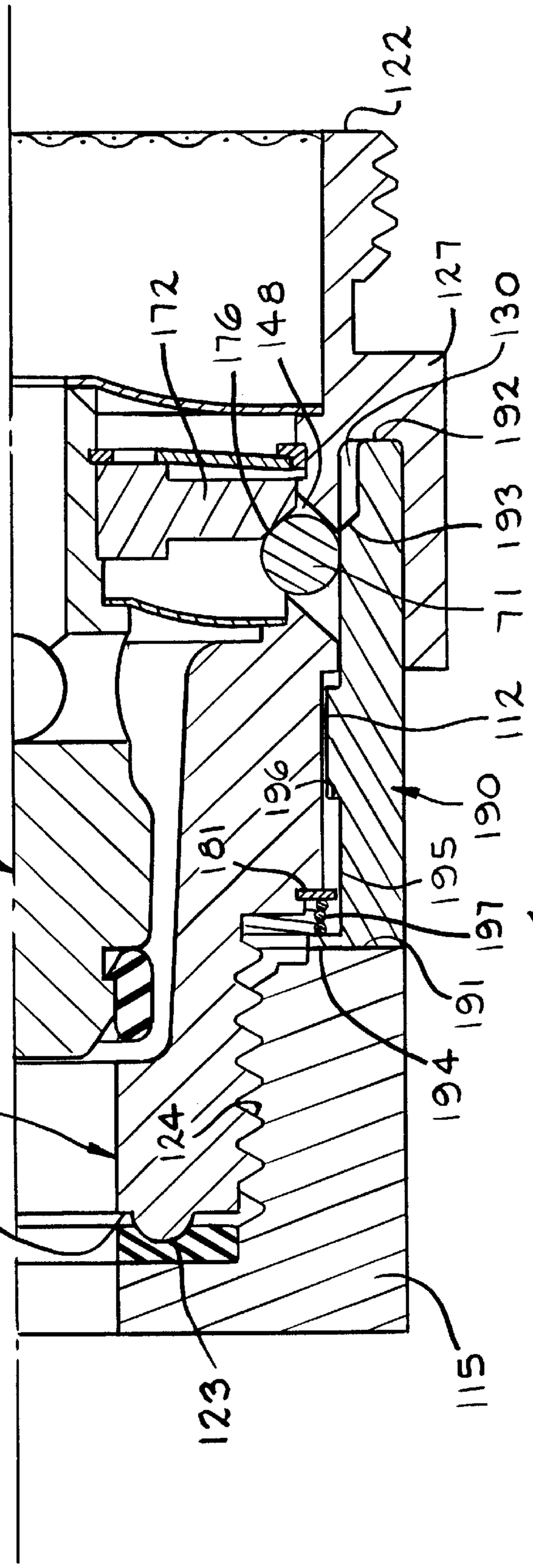
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FIG. 6

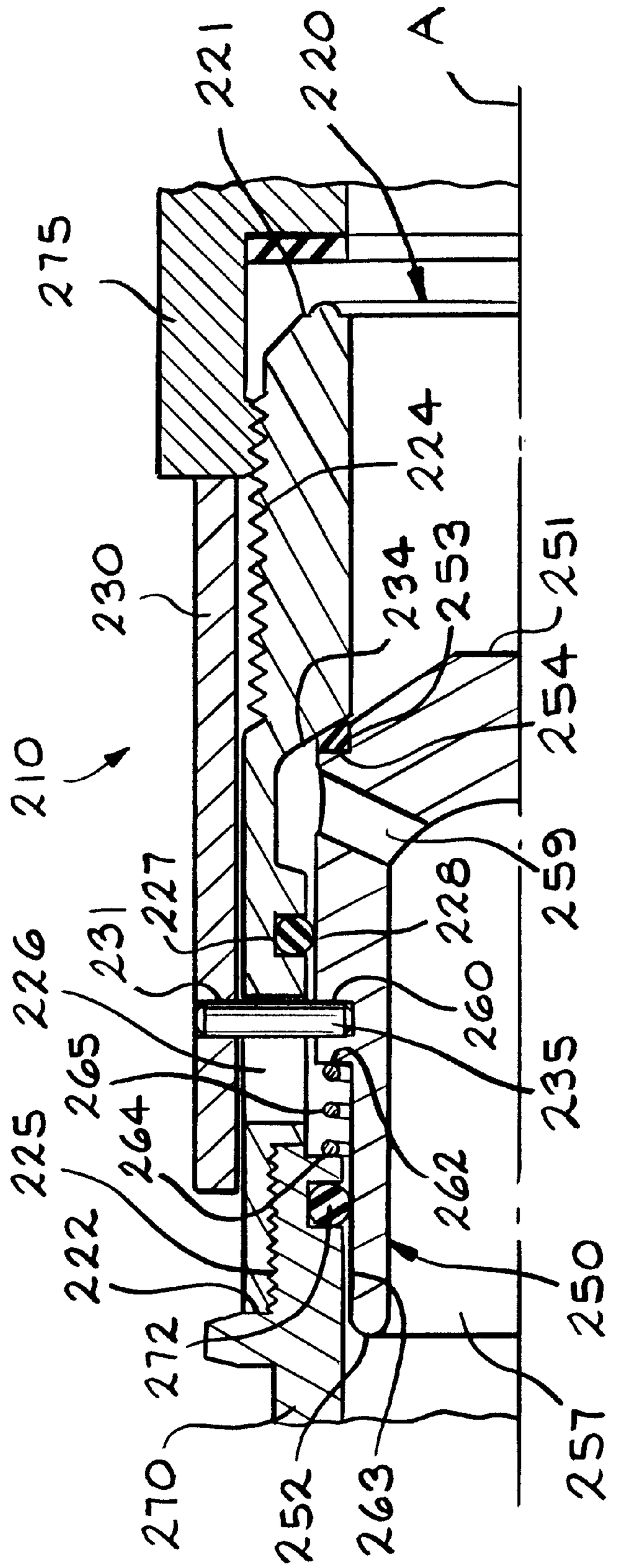
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FIG. 7

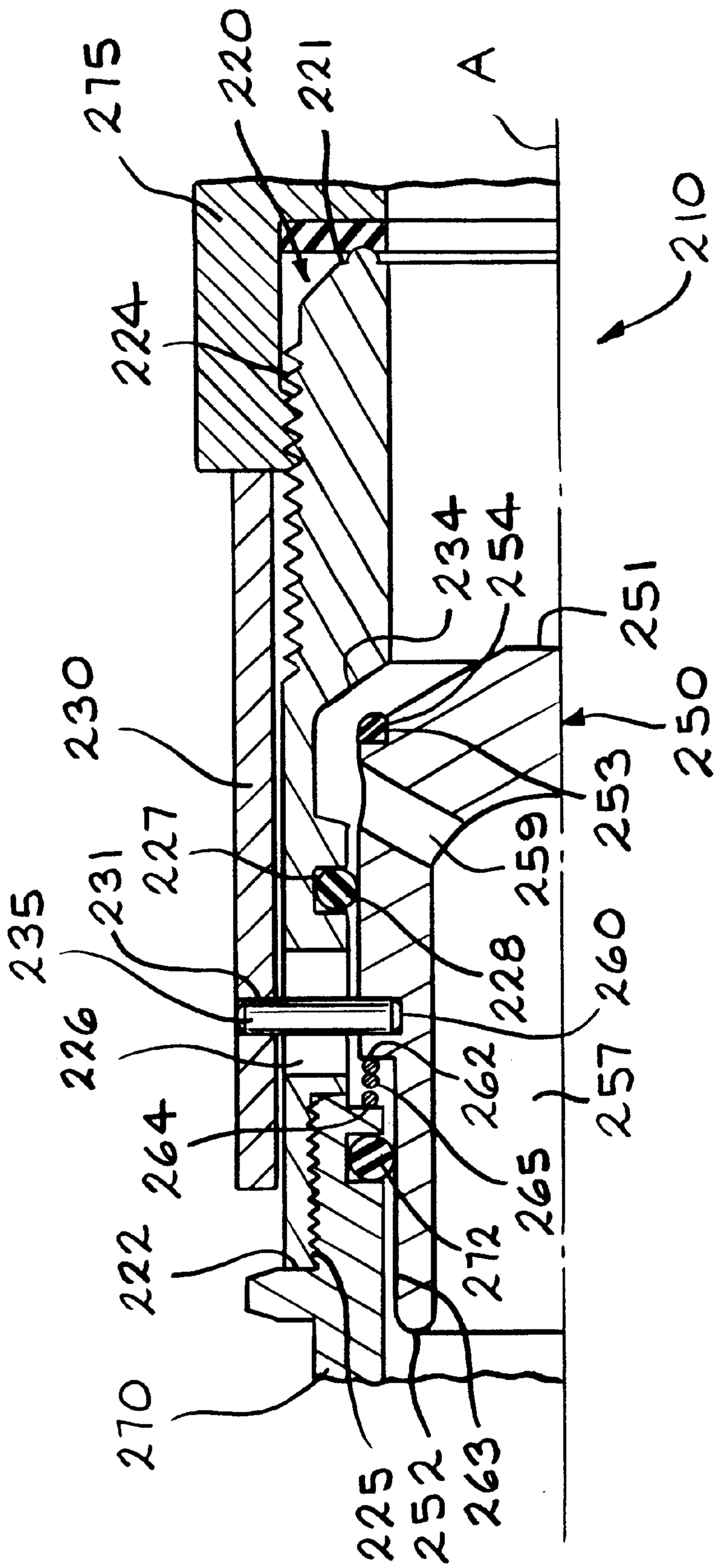
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FIG. 8

VALVE ASSEMBLY

The present invention relates to a valve assembly which can be used for controlling the flow of either gases or liquids. When used for controlling the flow of gases, it can function as a dry break valve for sealing inlet and outlet ports of a mass flow controller or similar device. When used for liquids, it can be part of a hydraulic fluid flow system.

BACKGROUND OF THE INVENTION

With respect to its use as a dry break valve, semiconductor manufacturing involves building up layers of conducting and insulating films on silicon wafers to produce miniature transistors. These films are deposited or etched using reactive gases, liquified gases or liquids. It is imperative to get precise properties of the films and to get repeatability from wafer to wafer. One of the requirements for achieving precision is to deliver exactly the flow rate of gas called for by the process and at exactly the required pressure and temperature. This is achieved by using several reactant delivery components. These are arranged into a "gas box" (sometimes called a "gas panel" or a "gas jungle" or a "gas tray"). A gas box contains an assembly of "gas sticks," each of which monitors and controls the flow of one gas to the process chamber. A gas stick is built around a component called a mass flow controller. The mass flow controller controls the flow rate of gas (or in some instances liquid). It is a thermal based device that reads the flow rate based on the temperature rise of the gas as it passes through the device. The temperature rise is calibrated to flow for the particular gas.

At the completion of the construction of the mass flow controller, the manufacturer may purge the mass flow controller with a gas such as dry argon. At the completion of the purged cycle, it is desired that the purge gas (i.e., dry argon for example) be maintained in the mass flow controller under a pressure on the order of 2 psig during shipment of the mass flow controller to the customer.

SUMMARY OF THE PRESENT INVENTION

The valve assembly of the present invention is self-sealing. It has one end designed to mate with a standard VCR assembly such as that manufactured and sold by Cajon Company, Macedonia, Ohio to achieve a metal-to-metal seal which is desirable for high purity assemblies requiring vacuum or a positive pressure. See for example, U.S. Pat. No. 5,605,358.

The dry break assembly valve of the present invention has its own internal valving which permits the introduction of the purging gas such as dry argon into the mass flow controller. Following introduction of such purging gas in a quantity sufficient to provide a build-up of pressure, for example on the order of 2 psig, the internal valving of the dry break assembly may be closed thereby retaining such purging gas within the mass flow controller. The dry break assembly of the present invention may then be shipped with the mass flow controller and remain with it during shipping and storage until its installation in a gas stack. By maintaining a positive pressure on the purge gas within the mass flow controller assembly, it is assured that contaminants cannot enter the mass flow controller.

IN THE DRAWINGS

FIG. **1** is a sectional view in elevation of one embodiment of the valve assembly of the present invention in the closed position.

FIG. **2** is a view similar to FIG. **1** showing the valve assembly in the open position.

FIG. **3** is an exploded view in perspective of the valve assembly.

FIG. **4** is a plan view of the actuator element of the valve assembly of the present invention.

FIG. **5** is a sectional view in elevation of a second embodiment of the present invention showing the valve assembly in the closed position.

FIG. **6** is a view similar to FIG. **5** showing the valve assembly in the open position.

FIG. **7**. is a sectional view in elevation of a third embodiment of the present invention showing the valve assembly in the closed position.

FIG. **8** is a view similar to FIG. **7** showing the valve assembly in the open position.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings, there is shown a valve assembly **10** having a body **20** extending along an axis A from a first end **21** to a second end **22**. A circumferential sealing bead **23** is provided at the first end **21**. The sealing bead **23** is intended to achieve a metal-to-metal seal such as that shown for example in U.S. Pat. No. 5,605,358. Externally, the body is provided with first outwardly facing threads **24** in the vicinity of the first end **21** and second outwardly facing threads **25** adjacent the second end **22**.

Adjacent the second outwardly facing threads **25** is a recessed cylindrical wall portion **26** followed by an enlarged base **27** having a generally hexagonal cross-section defined by a series of flat faces **27**A, **27**B, **27**C, **27**D and **27**E which are shown and another face which is not visible in the drawings. A radial shoulder **28** extending outwardly from the cylindrical wall **26** defines the end of the enlarge base **27** facing the second end **22**. The opposing end of the enlarge base **27** facing the first end **21** is provided with a cylindrical recess or groove **30**. The groove **30** is defined by an outer cylindrical wall **30**A and an inner cylindrical wall **30**B and a bottom **30**C. A radial shoulder **31** extends inwardly from the cylindrical wall **30**B and joins with an annular groove **32** adjacent the first threads **24**. Extending inwardly from the cylindrical wall **30**B is an outwardly facing groove **33** which is spaced axially a short distance from the radial shoulder **31**.

Internally the body **20** has an inwardly facing cylindrical wall **34** adjacent the first end **21** defining an inlet. Extending radial outwardly from the cylindrical wall **34** is an annular valve seat **35** from which extends in a generally axial direction but tapering outwardly a conical wall section **36**. A radial shoulder **37** extends outwardly from the conical wall section **36** to a cylindrical step **38** extending to a radially extending seat **39**. A second cylindrical step **40** extends to a second radially extending seat **41**. An inwardly facing cylindrical wall section **42** extends in an axial direction from the second radially extending seat **41** to an outwardly extending diaphragm seat **43**. A third inwardly facing cylindrical wall section **44** extends from the diaphragm seat **43** to the second end **22**.

An inwardly facing annular groove **46** extends outwardly from the second inwardly facing cylindrical wall **42**. A plurality of ball receiving apertures **48**, preferably three in number, extend through the wall member defined by the outwardly facing cylindrical wall surface **30**B and the second inwardly facing cylindrical wall **42**. Preferably the ball receiving apertures **48** extend through the wall section at an

angle of **450** relative to the axis A and taper outwardly in a direction toward the first end **21**.

Positioned within the body **20** is a poppet **50** which extends axially from a first sealing end **51** to a second open end **52**. The portion of the poppet adjacent the sealing end is provided with a retention groove **53** in which is positioned an annular seal **54** which extends axially to a sealing end **55** positioned for sealing engagement with the radial valve seat **35** when the poppet **50** is in the closed position shown in FIG. **1**. The poppet **50** has a stem **56** with an axial passageway **57** extending to the second open end **52**. The axial passageway **57** extends to a juncture with a plurality of radially extending passageways **59**. The portion of the poppet between the first end **51** and the passageways **59** is solid and includes an annular wall **61**. The outer portion of the annular seal **54** and the annular wall **61** are both spaced from the conical wall section **36** of the body **20** and cooperate therewith to define an annular passageway **62** communicating with the passageways **59** and the passageway **57** to permit the flow of fluid through the body **20** when the poppet **50** is in the open position as shown in FIG. **2**.

Externally, the stem **56** is provided with a first radially extending shoulder **63** and a second, radially smaller shoulder **64** between the shoulder **63** and the second open end **52**. The stem **56** is also provided with an outwardly facing annular groove **65** in the area between the smaller shoulder **64** and the second open end **52**.

The poppet **50** is retained in the body **20** by means of an inner diaphragm **60** and an outer diaphragm **70**. The inner diaphragm **60** has an outer circumferential edge which is welded to the radially extending seat **39** of the body **20** and an inner circumferential edge which is welded to the radially extending shoulder **63** of the poppet stem.

The outer diaphragm **70** has an outer circumferential edge welded to the diaphragm seat **43** of the body **20** and an inner circumferential edge welded to the second open end **52** of the poppet **50**. The inner circumferential edge of the outer diaphragm **70** defines an opening through which fluid passing through the passageway **57** may pass. The inner diaphragm **60** and outer diaphragm **70** may be formed of a high nickel bearing alloy such as one marketed under the trademark Elgiloy® which provides good resistance to stress cracking as a result of axial movement of the respective inner circumferential edges of the diaphragms relative to their outer circumferential edges upon axial movement of the poppet **50** in the body **20** as hereinafter described.

Positioned in each of the apertures **48** is a spherical ball **71**. Also, positioned in the body **20** is a thrust washer **72** having an inner cylindrical wall **73** encircling the stem **56** of the poppet and an outer cylindrical wall **74** slideably engaged to the second inwardly facing cylindrical wall **42** of the body. The thrust washer **72** is retained in a fixed position on the stem **56** by means of (1) a snap ring **75** positioned in the outwardly facing annular groove **65** engaging the outer surface of the thrust washer **72** and (2) the inner surface of the thrust washer **72** engaging the small radially extending shoulder **64**.

The thrust washer **72** is provided with a tapered camming surface **76** which tapers inwardly toward the axis A and toward the first end **21** of the body **20**. As may be seen in comparing FIGS. **1** and **2**, movement of the balls **71** radially inwardly causes them to slide along the tapered camming surface **76** to urge the poppet **50** from the closed position shown in FIG. **1** at which the sealing end **55** of the annular seal **54** is sealingly engaged to the valve seat **35** of the body **20** to a position to the right as shown in FIG. **2** at which the sealing end **55** is spaced from the valve seat **35** thereby opening the valve assembly **10** to permit the flow of fluid into the first end **21** through the opening defined by the cylindrical wall **34** and into the annular passageway **62**, through the passageways **59**, the stem passageway **57** and out of the outlet end **22**. Upon movement of the balls **71** radially outwardly, the thrust washer **72** and poppet **50** may return to the sealed position shown in FIG. **1**. A Belleville spring **78** is provided to urge the thrust washer **72** and poppet **50** to the sealed positioned of FIG. **1**. A snap ring **79** is retained in the inwardly facing annular groove **46** of the body and engages the outer edge of the Belleville spring **78**. The inner edge of the Belleville spring **78** is in contact with the outer surface of the thrust washer **72**.

In order to move the balls from an outer position to a radially inner position, there is provided an actuator **80** which is positioned in the annular recess **30** of the body **20**. The actuator **80** is rotatably retained in the annular recess **30** by means of a snap ring **81** positioned in and extending outwardly from the outwardly facing annular groove **33** of the body and into an aligned inwardly facing annular groove **82** of the actuator **80**. The outer surface of the actuator **80** is cylindrical. The actuator **80** is rotatably moveable in the outer portion of the annular recess **30**. As may be seen in FIGS. **1** and **2** and in greater detail in FIG. **4**, the inwardly facing surface **84** of the actuator **80** is contoured to provide three sets of camming surfaces **84**A, **84**B and **84**C. Each of the camming surfaces **84**A, **84**B and **84**C is engageable by and controls the radially inward and outward movement of one of the balls **71** upon rotation of the actuator **80**. Centrally positioned at the radially outermost portion of each of the inwardly facing camming surfaces **84**A, **84**B and **84**C is a detent **85** extending outwardly a slight amount from adjacent portions. Upon rotation of the actuator **80** to a position at which the balls **71** engage the respective detents **85**, there will be a slight clicking sound which will provide an indication to the operator that the balls **71** are at their maximum outward position and that the poppet is in its sealed position with the sealing end **55** of the annular seal **54** sealingly engaged to the valve seat **35** as shown in FIG. **1**.

The end of the actuator **80** facing the first end **21** of the body **20** is provided with a series of recesses **86**, preferably six in number, which may be engaged by a spanner wrench in order to effect rotation of the actuator **80**.

If the valve assembly **10** is to be used with a mass flow controller or other apparatus requiring high purity, it will be desirable to have a filter **87** secured to the second outlet end **22** of the body.

In operation, the valve assembly **10** may have its second end **22** threadably engaged to a threaded port of a mass flow controller or other unit into which fluid is to be directed. A source of fluid may be threadably engaged to the threads **24** at the first inlet end **21** of the body **20**. When it is desired to introduce fluid through the valve assembly **10**, a spanner wrench may engage the recesses **86** of the actuator **80** and rotate the actuator **80** from a position at which the detents **85** are aligned with the balls **71** to a position approximately 60° therefrom, at which position the balls **71** will engage the radially inner most portions of the respective camming surfaces **84**A, **84**B and **84**C. Upon such rotation of such actuator, the camming surfaces **84**A, **84**B and **84**C will urge the balls **71** radially inwardly thereby causing the balls **71** to move against the tapered camming surface **76** of the thrust washer **72** urging such thrust washer **72** and the poppet **50** carried thereby to the right to the open position of FIG. **2**.

When it is desired to close the valve assembly **10**, the actuator **80** will be rotated to the position at which the

detents **85** are aligned with the balls **71** thereby permitting the balls **71** to move to their outermost positions. With the balls so positioned, the Belleville spring **78** urges the thrust washer **72** and the poppet **50** toward the first end **21** causing the sealing end **55** of the annular seal **54** to sealingly engage the valve seat **35** closing the valve assembly **10**.

Referring now to FIGS. **5** and **6**, there is shown another embodiment of valve assembly generally designed by the numeral **110**. This valve assembly **110** may be actuated and moved from the closed to open position by rotatable engagement of a nut on the body thereby causing axial movement of an actuator ring. Similar to the embodiment of FIGS. **1** through **4**, this embodiment utilizes a series of balls being urged radially inwardly to effect movement of the poppet from a sealed closed position to an open position.

The valve assembly **110** of the embodiment of FIGS. **5** and **6** utilizes a body **120** and poppet **150** which are similar to the body **20** and poppet **50** of the embodiment of FIGS. **1** through **4**. Accordingly, only those features which are different will be described in detail. The numbering of members of this embodiment will follow a similar sequence as the corresponding portions of the embodiment of FIGS. **1** through **4** except that the numbers will be in the 100 series.

As shown in FIGS. **5** and **6** there is provided a body **120** extending from a first inlet end **121** to a second outlet end **122**. The body has a sealing bead **123** at the inlet end and outwardly facing threads **124** adjacent thereto.

In the embodiments of FIGS. **5** and **6**, there is provided an outer sleeve **190** which is axially moveable in the recess **130** of the body **120**. The enlarged base **127** of the body **120** has been lengthened axially from the base **27** shown in the embodiment of FIGS. **1** through **4** in order to provide a deeper recess **130** in which the end of the outer sleeve **190** may slide.

The outer sleeve **190** extends from a first end **191** to a second end **192**. Spaced from the second end **192** is an inwardly tapering camming surface **193** which is positioned to contact the balls **71** when the portion of the outer sleeve **190** between the second end **192** and the camming surface is moved axially within the recess **130** toward the second end **122** of the body **120**.

The outer sleeve **190** also is provided with a radially inwardly extending first shoulder **194** at the first end **191** extending radially inwardly from its inner surface **195** and a second shoulder **196** spaced therefrom and also extending radially inwardly from the inner surface **195**.

The body **120** is slightly longer than the body **20** of the embodiments of FIGS. **1** and **2** and is provided with an outwardly facing cylindrical wall surface **112** axially positioned between the threads **124** and the apertures **148** in which the balls **71** are retained. A snap ring **181** is positioned in an outwardly facing annular groove extending inwardly from the cylindrical wall surface **112**. A compression spring **197** is positioned between the shoulder **194** and the snap ring **181** and urges the outer sleeve **190** in a direction toward the first end **121** such that the camming surface **15** is out of engagement with the balls **71**. Engagement of the second shoulder **196** with the snap ring **181** prevents the outer sleeve **190** from being pushed completely out of the recess **130**.

A nut **115** is engaged to the threads **124**. Rotation of the nut **115** on the threads **124** to move the nut **124** toward the second end **122** moves the outer sleeve **190** against the urging action of the spring **197** to a position where its camming surface **193** engages the balls **171** forcing them radially inwardly to contact the tapered camming surface **176** of the thrust washer **172** to move the poppet **150** from the closed position of FIG. **5** to the open position of FIG. **6**.

Referring to FIGS. **7** and **8**, there is provided a further embodiment of valve assembly **210** which, similar to the embodiment of FIGS. **5** and **6** may be moved from a closed to open position by simple rotation of a nut to cause axial movement of a sleeve which in turn causes axial movement of the poppet. There is provided a body **220** extending along an axis A from a first end **221** to a second end **222**. The body **220** has outwardly facing threads **224** adjacent the first end **221** and inwardly facing threads **225** adjacent the second end **222**. A plurality of elongated apertures or slots **226**, preferably three to six in number, are formed in the body **220** at substantially equally spaced apart circumferential areas. The slots **226** extend in a direction generally parallel to the axis A.

Internally, the body **220** is provided with an inwardly facing annular groove **227** in which is positioned an O-ring seal **228**. A valve seat **234** is positioned axially between the first end **221** and the annular groove **227**.

Encircling the body **220** and axially moveable relative thereto is an outer sleeve **230**. The outer sleeve **230** has a plurality of apertures **231** equal in number to the number of slots **226** and positioned circumferentially such that each of the apertures **231** is aligned with one of the slots **226**. Each of the apertures **231** has a pin **235** frictionally or otherwise permanently retained therein. Each pin **231** extends radially inwardly from the outer sleeve **230** and through the aligned slot **226** to an end which is radially inwardly of the inner surface of the body **220**.

Positioned within the body **220** is a poppet **250** which extends axially from a first sealing end **251** to a second open end **252**. The portion of the poppet **250** in the vicinity of the first end **251** is provided with a retention groove **253** in which is positioned an annular seal **254** which is positioned for sealing engagement with valve seat **234** when the poppet **250** is in the closed position shown in FIG. **7**. Although the poppet **250** could have a variety of configurations, including a configuration similar to that shown in FIGS. **1** through **4**, poppet **251** as shown in FIGS. **7** and **8** is provided with an axial passageway **257** and a plurality of angled passageways **259** disposed circumferentially around the poppet **251** in an axial position between the annular seal **254** and the O-ring **228** of the body **220**. The exterior surface of the poppet **250** in the area of the O-ring **228** is sized such that the O-ring **228** is in sealing engagement therewith. That portion of the poppet **250** between the annular seal **254** and the first end **251** is closed. As a result, when the annular seal **253** is sealingly engaged to the valve seat **234**, the valve assembly **250** is closed to the flow of fluid.

Externally, the poppet **250** is provided with a series of recesses **260** equal in number to and circumferentially positioned to receive therein the ends of the pins **235**.

Positioned axially between the recesses **260** and the second end **252** is a radially outwardly extending shoulder **262**. An outwardly facing cylindrical wall **263** is positioned between the radial shoulder **262** and the second end **252**.

A threaded connector **270** is engaged to the threads **225** of the body. The threaded connector has a forward end flange **264** and an annular groove in which is positioned an O-ring **272**. The interior surface of the connector **270** and the O-ring **272** are sized to provide sealing engagement between the O-ring **272** and the outwardly facing cylindrical wall **263** of the poppet **250**. A compression spring **265** is positioned in space between the flange **264** and the radial shoulder **262** of the poppet **250**.

An internally threaded nut **275** is engaged to the outwardly extending threads **224** of the body **220**. When it is desired to open the valve assembly **210**, the nut **275** is rotated on the threads **224** to move the nut toward the second end **222** of the body **220**. The leading end of the nut **275** will push against the end of the outer sleeve **230** moving it axially toward the second end **222** of the body **220**. Such axial movement of the outer sleeve **230** will move its pins **231** in the slots **226** of the body **220** and will carry with them the poppet **250** by virtue of the pins **235** extending into the recesses **260** of the poppet **250**. Such movement will move the poppet **250** from the sealed position of FIG. **7** to the open position of FIG. **8**, at which position, the annular seal **254** is spaced from the valve seat **234** thereby permitting fluid to flow into the open end **221** of the body **220**, through the space between the annular seal **254** and the valve seat **234**, through the tapered passageways **259** and out of the axial passageway **257**.

Upon rotation of the nut **275** in the opposite direction, the outer sleeve **230** will be urged toward the first end **221** of the body **220** by the urging action of the compression spring **265** which will urge the poppet **250** to a closed position at which the annular seal **254** is sealingly engaged with the valve seat **234**.

Other modifications will become readily apparent to those skilled in the art. Accordingly, the scope of the present invention should be determined only by the scope of the claims.

We claim:

1. A valve assembly comprising

(a) a body **(20)** extending along an axis from a first end **(21)** to a second end **(22)**, said body **(20)** having a passageway defined by inwardly facing wall sections, a shoulder **(35)** in the vicinity of said first end **(21)** extending inwardly from one of said inwardly facing wall sections **(36)**;

(b) a poppet **(50)** contained within said body and slideably moveable axially in said passageway, said poppet **(50)** extending from a first closed end **(51)** to a second open end **(52)** and having an annular seal **(54)** in the vicinity of said first closed end **(51)** engageable with said shoulder **(35)** and, when so engaged, cooperating with said closed end **(51)** to block the flow of fluid between said body first end **(21)** and second end **(22)**, and at least one opening **(57, 59)** positioned between said annular seal **(54)** and said second open end **(22)**, said opening **(57, 59)** permitting the flow of fluid through said body first end **(21)** to said body second end **(22)** when said annular seal **(54)** is spaced from said shoulder **(35)**;

(c) a spring yieldingly urging said poppet **(50)** toward said body shoulder **(35)**; and

(d) an actuator **(80)** encircling a portion of said body **(20)** and rotatable relative thereto, rotation of said actuator **(80)** on said body **(20)** causing axial movement of said poppet **(50)** within said body **(20)** to move said annular seal **(54)** from a position engaged to said shoulder **(35)** to a position spaced from said shoulder **(35)**.

2. The valve assembly according to claim **1** further including one or more camming elements extending through said body, rotation of said actuator imparting to said camming elements movement inwardly toward said axis.

3. The valve assembly according to claim **2** wherein said actuator includes a (i) threaded nut threadedly engaged to said body and (ii) an axially moveable sleeve having a camming surface slidingly engaged to said camming elements.

4. The valve assembly according to claim **1** wherein said body has threads in the vicinity of said first end and said actuator is engaged to said threads, rotation of said actuator resulting in axial movement of said actuator on said body.

5. The valve assembly according to claim **4** wherein said body has a plurality of slots in diverse circumferential positions and further including a sleeve encircling said body, a plurality of pins engaged to said sleeve and said poppet and extending through said slots, said actuator engaged to said sleeve.

6. A valve assembly comprising

(a) a body **(20)** extending along an axis from a first end **(21)** to a second end **(22)**, said body **(20)** having a passageway defined by inwardly facing wall sections, a shoulder **(35)** in the vicinity of said first end **(21)** extending inwardly from one of said inwardly facing wall sections **(36)**;

(b) a poppet **(50)** positioned in and axially moveable in said passageway, said poppet **(50)** extending from a first closed end **(51)** to a second open end **(52)** and having an annular seal **(54)** in the vicinity of said first closed end **(51)** engageable with said shoulder **(35)** and, when so engaged, cooperating with said closed end **(51)** to block the flow of fluid between said body first end **(21)** and second end **(22)**, and at least one opening **(57, 59)** positioned between said annular seal **(54)** and said second open end **(22)**, said opening **(57, 59)** permitting the flow of fluid through said body first end **(21)** to said body second end **(22)** when said annular seal **(54)** is spaced from said shoulder **(35)**;

(c) a spring yieldingly urging said poppet **(50)** toward said body shoulder **(35)**;

(d) an actuator **(80)** encircling a portion of said body **(20)** and rotatable relative thereto, rotation of said actuator **(80)** on said body **(20)** causing axial movement of said poppet **(50)** in said body **(20)** to move said annular seal **(54)** from a position engaged to said shoulder **(35)** to a position spaced from said shoulder **(35)**;

(e) one or more camming elements **(71)** extending through said body, rotation of said actuator imparting to said camming elements **(71)** movement inwardly toward said axis; and

(f) a thrust washer **(72)** encircling said poppet **(50)** in fixed axial position relative thereto positioned in and axially moveable in said body **(20)**, said thrust washer **(72)** having a camming surface **(76)** engaged to said camming elements **(71)**.

7. The valve assembly according to claim **6** further including a first diaphragm sealingly engaged to said poppet and to said body, said first diaphragm being positioned axially between said sealing abutment and said thrust washer.

8. The valve assembly according to claim **7** further including a second diaphragm sealingly engaged to said poppet and to said body, said second diaphragm being positioned axially between said thrust washer and said second end.

9. A valve assembly comprising

(a) a body **(20)** extending along an axis from a first end **(21)** to a second end **(22)**, said body **(20)** having a passageway defined by inwardly facing wall sections, a shoulder **(35)** in the vicinity of said first end **(21)** extending inwardly from one of said inwardly facing wall sections **(36)**;

(b) a poppet **(50)** positioned in and axially moveable in said passageway, said poppet **(50)** extending from a

first closed end (**51**) to a second open end (**52**) and having an annular seal (**54**) in the vicinity of said first closed end (**51**) engageable with said shoulder (**35**) and, when so engaged, cooperating with said closed end (**51**) to block the flow of fluid between said body first end (**21**) and second end (**22**), and at least one opening (**57**, **59**) positioned between said annular seal (**54**) and said second open end (**22**), said opening (**57**, **59**) permitting the flow of fluid through said body first end (**21**) to said body second end (**22**) when said annular seal (**54**) is spaced from said shoulder (**35**);

(c) a spring yieldingly urging said poppet (**50**) toward said body shoulder (**35**);

(d) an actuator (**80**) encircling a portion of said body (**20**) and rotatable relative thereto, rotation of said actuator (**80**) on said body (**20**) causing axial movement of said poppet (**50**) in said body (**20**) to move said annular seal (**54**) from a position engaged to said shoulder (**35**) to a position spaced from said shoulder (**35**);

(e) a plurality of camming elements (**71**) extending through said body (**20**), each said camming element (**71**) moveable from an outer position to an inner position closer to said axis; and

(f) a thrust washer (**72**) encircling said poppet (**50**) in a fixed axial position relative thereto positioned in and axially moveable in said body (**20**), said thrust washer (**72**) having a camming surface (**76**) engaged to said camming elements (**71**),

movement of said camming elements (**71**) inwardly toward said axis against said camming surface (**76**) moving said thrust washer (**72**) and said poppet (**50**) axially, rotation of said actuator forcing said camming elements (**71**) inwardly toward said axis.

10. The valve assembly according to claim **9** wherein said actuator is maintained in a fixed axial position relative to said body and has contoured inner surface portions each engaged to one of said camming elements, each said contoured inner surface portion including an outer segment and an inner segment positioned closer to said axis than said outer segment.

11. The valve assembly according to claim **10** further including a detent in at least one of said outer segments, said detent extending further from said axis than adjacent portions of said outer segment.

12. A valve assembly comprising

(a) a body (**20**) extending along an axis from a first end (**21**) to a second end (**22**), said body (**20**) having a passageway defined by inwardly facing wall sections, a shoulder (**35**) in the vicinity of said first end (**21**) extending inwardly from one of said inwardly facing wall sections (**36**);

(b) a poppet (**50**) positioned in and axially moveable in said passageway, said poppet (**50**) extending from a first closed end (**51**) to a second open end (**52**) and having an annular seal (**54**) in the vicinity of said first closed end (**51**) engageable with said shoulder (**35**) and, when so engaged, cooperating with said closed end (**51**) to block the flow of fluid between said body first end (**21**) and second end (**22**), and at least one opening (**57**, **59**) positioned between said annular seal (**54**) and said second open end (**22**), said opening (**57**, **59**) permitting the flow of fluid through said body first end (**21**) to said body second end (**22**) when said annular seal (**54**) is spaced from said shoulder (**35**);

(c) a spring yieldingly urging said poppet (**50**) toward said body shoulder (**35**);

(d) an actuator (**80**) encircling a portion of said body (**20**) and rotatable relative thereto, rotation of said actuator (**80**) on said body (**20**) causing axial movement of said poppet (**50**) in said body (**20**) to move said annular seal (**54**) from a position engaged to said shoulder (**35**) to a position spaced from said shoulder (**35**);

(e) threads in the vicinity of said body first end, said actuator being engaged to said threads, rotation of said actuator resulting in axial movement of said actuator on said body;

(f) a plurality of balls extending through said body, rotation of said actuator imparting to said balls movement inwardly toward said axis; and

(g) a thrust washer encircling said poppet in fixed axial position relative thereto positioned in and axially moveable in said body, said thrust washer having a camming surface engaged to said balls, movement of said balls inwardly toward said axis against said camming surface moving said thrust washer and said poppet axially.

13. A valve assembly comprising

(a) a body extending along an axis from a first end to a second end, said body including a passageway, a sealing abutment in the vicinity of said first end, an enlargement having a recess with an open end encircling said axis and facing toward one of said body first or second ends and one or more apertures extending between said recess and said passageway;

(b) a poppet having a sealing end and an open end positioned in said body passageway for movement axially therein, said poppet having an annular seal in the vicinity of said sealing end engageable with said sealing abutment and one or more passageways between said annular seal and said open end;

(c) one or more moveable camming members positioned in said apertures;

(d) an actuator rotatably positioned in said recess, said actuator having an interior surface slidably engaged with said camming members, said interior surface being contoured with one or more first sections and second sections adjacent thereto, said first sections being closer to said axis than said second sections;

(e) a thrust washer positioned in said body passageway for movement axially therein, said thrust washer affixed to said poppet to impart axial movement thereto upon axial movement of said thrust washer; rotation of said actuator from a position at which said second sections are engaged to said camming members to a position at which said first sections are engaged to said camming members moving said poppet from a position at which said annular seal is engaged to said body sealing abutment to a position at which said annular seal is spaced from said body sealing abutment.

14. The valve assembly according to claim **13** wherein said actuator has a detent in at least one of said second sections, said detent extending further from said axis than adjacent portions of said second sections.

15. The valve assembly according to claim **13** further including a resilient member yieldingly urging said poppet to a position at which said annular seal is sealingly engaged to said sealing abutment when said actuator interior surface second sections are engaged to said camming members.

16. The valve assembly according to claim **13** wherein said camming members are balls and said thrust washer has a camming surface tapering inwardly toward said axis in a direction toward said first end.

17. The valve assembly according to claim **13** further including a first diaphragm sealingly engaged to said poppet and to said body, said first diaphragm being positioned axially between said sealing abutment and said thrust washer.

18. The valve assembly according to claim **17** further including a second diaphragm sealingly engaged to said poppet and to said body, said second diaphragm being positioned axially between said thrust washer and said second end.

19. A method for controlling the flow of fluid comprising the steps of

(a) providing a valve assembly having

(i) a body (**20**) extending along an axis from a first end (**21**) to a second end (**22**), said body (**20**) having a passageway defined by inwardly facing wall sections (**34**, **36**, **42**), a sealing abutment (**35**) in the vicinity of said first end (**21**) extending inwardly from one of said inwardly facing wall sections (**36**);

(ii) a poppet (**50**) positioned in and axially moveable in said passageway, said poppet (**50**) extending from a first closed end (**51**) to a second open end (**52**) and having an annular seal (**54**) in the vicinity of said first closed end (**51**) engageable with said shoulder (**35**) and, when so engaged, cooperating with said closed end (**51**) to block the flow of fluid between said body first (**21**) and second end (**22**), and at least one opening (**57**, **59**) positioned between said annular seal (**54**) and said second open end (**22**), said opening (**57**, **59**) permitting the flow of fluid through said body first end (**21**) to said body second end (**22**) when said annular seal (**54**) is spaced from said shoulder (**35**);

(iii) one or more camming elements (**71**) extending through said body (**20**);

(iv) a spring yieldingly urging said poppet (**50**) toward said body sealing abutment (**35**); and

(v) an actuator (**80**) encircling a portion of said body (**20**) and rotatable relative thereto, said actuator having a surface (**84**) engaged to said camming elements (**71**), said surface (**84**) having first and second portions (**84**A, **84**B & **84**C), said first portion being closer to said axis that said second portions; and

(b) rotating said actuator (**80**) from a position at which said second portions are engaged to said camming elements (**71**) to a position at which said first portions (**84**A, **84**B & **84**C) are engaged to said camming elements (**71**) to thereby urge said camming elements (**71**) inwardly, said camming elements (**71**) imparting axial movement to said poppet (**50**) within said body (**20**) to move said annular seal (**54**) out of contact with said sealing abutment (**35**).

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,244,566 B1
DATED : June 12, 2001
INVENTOR(S) : Richard M. France & Russell L. Rogers

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Under (*) Notice section, please delete -- This patent issued on a continuation prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a) (2). --

Signed and Sealed this

Twenty-ninth Day of January, 2002

Attest:

Attesting Officer

JAMES E. ROGAN
Director of the United States Patent and Trademark Office